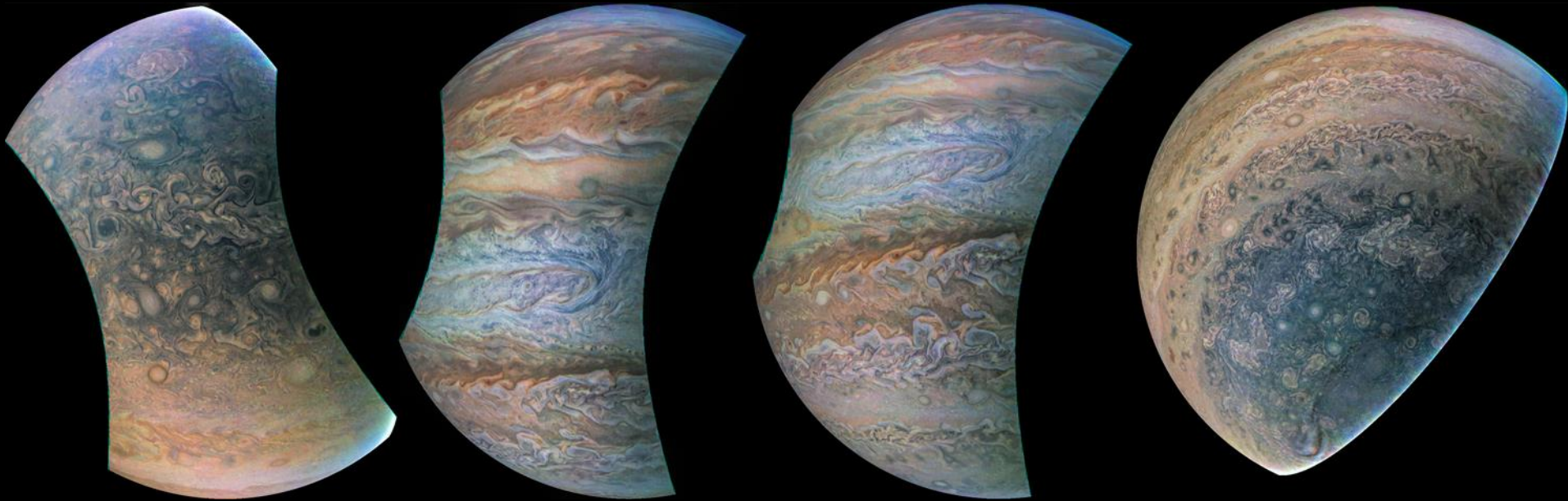


Results from the Juno's JunoCam: Science from an Outreach Experiment

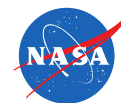


F. Tabataba-Vakili¹, C. J. Hansen², G. Orton¹,
M. Ravine³, M. Caplinger³, G. Eichstadt⁴, J.
Rogers⁵, T. Momary¹, S. Bolton⁶

NASA / JPL / SwRI / MSSS / Craig Sparks

1. Jet Propulsion Laboratory, California Institute of Technology; 2.
Planetary Science Institute; 3. Malin Space Science Systems; 4.
Independent scholar, Stuttgart, Germany; 5. British Astronomical Society;
6. Southwest Research Institute

June 2018
AOGS



Jet Propulsion Laboratory
California Institute of Technology

JunoCam

JunoCam is on the Juno payload to give the public an opportunity to participate in a planetary mission

Unique views of Jupiter's poles

Drove the camera design



NASA / JPL / MSSS / Roman Tkachenko

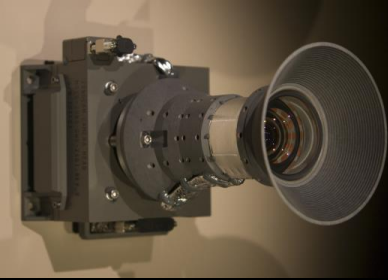
PJ1



South Pole

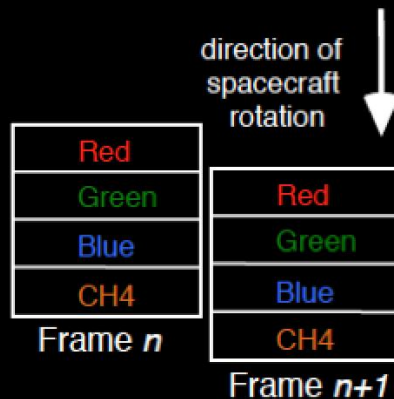
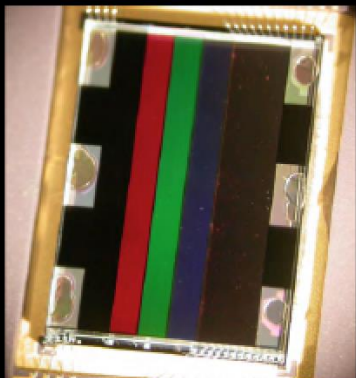
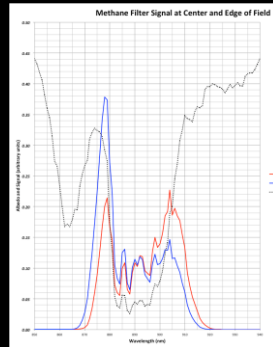
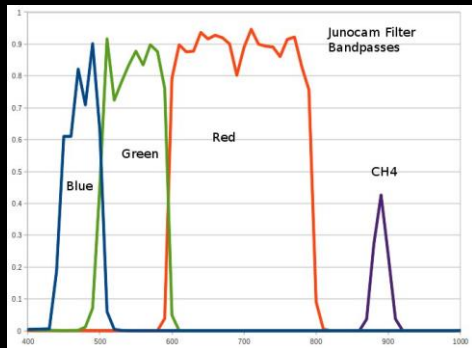


North Pole



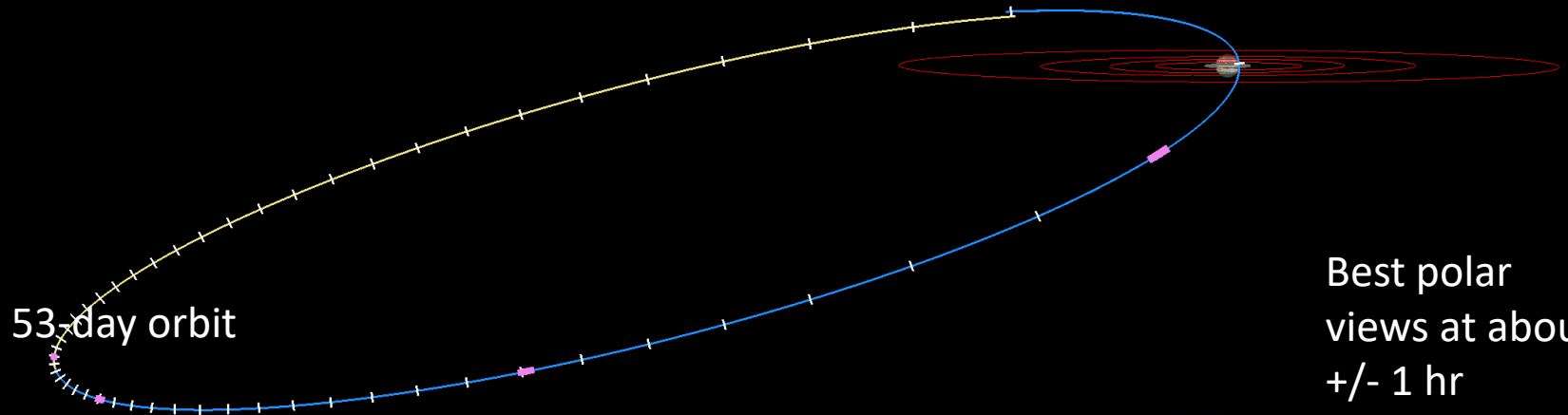
JunoCam Description

- JunoCam is a fixed-mounted, fixed field of view push-frame visible camera that images in four color bands
 - Broadband blue, green and red
 - Narrow methane band filter centered at 889 nm

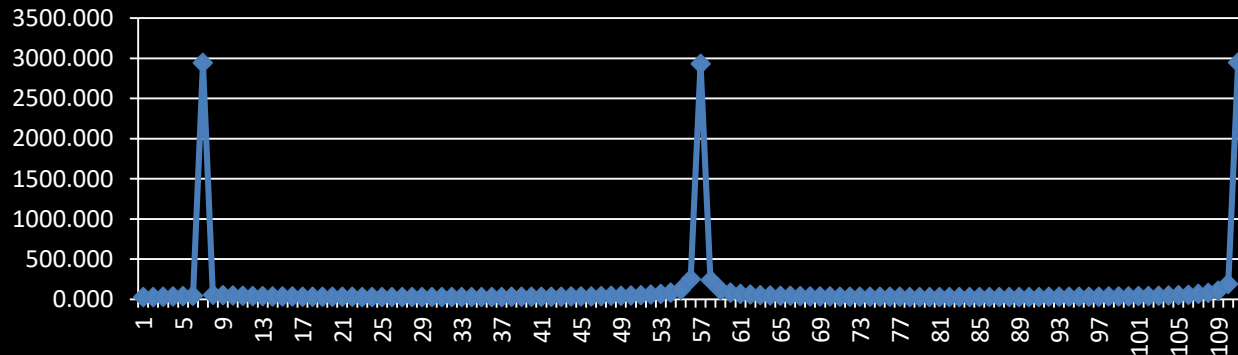


- *A JunoCam image is acquired as S/C rotation sweeps the 1600 pixel, 58° wide FOV across Jupiter*
- Time-delayed integration (TDI) used to build up SNR
- Built and operated by Malin Space Science Systems

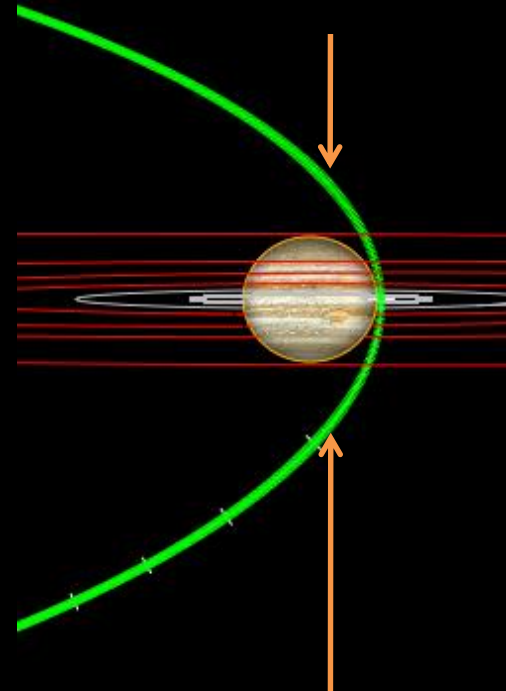
Juno's Elliptical Polar Orbit



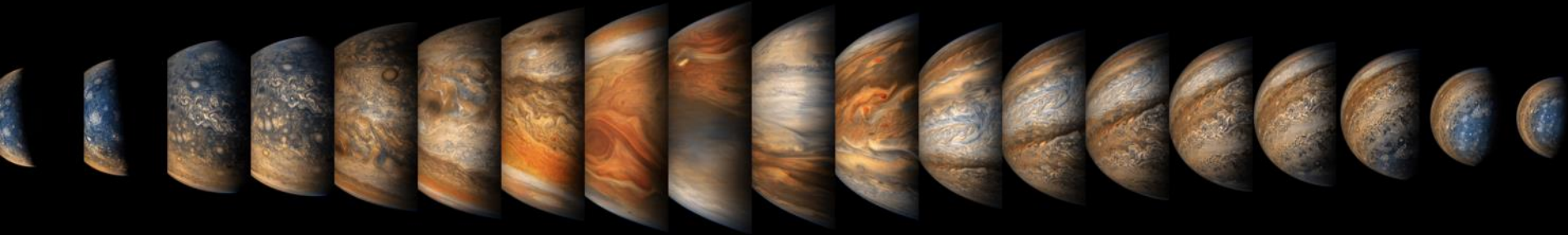
Jupiter is <50 pixels for most of Juno's orbit



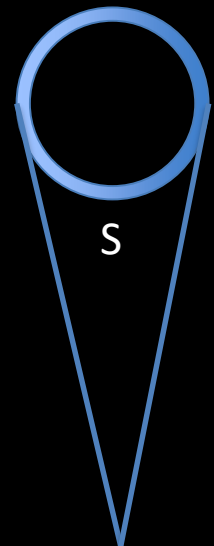
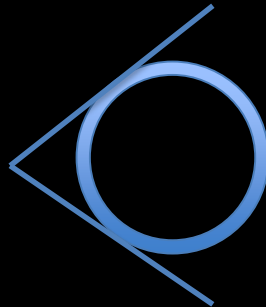
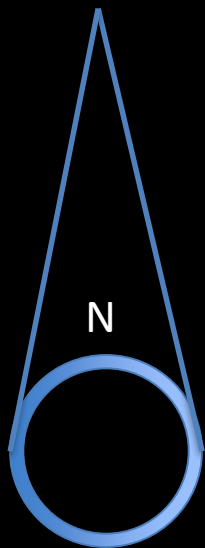
- Perijove swath begins ~1 hr before closest approach
- ~2h from north pole at minimum emission angle to south pole at minimum emission angle



PJ8 Perijove Pass



NASA / JPL / MSSS / Gerald Eichstädt / Sean Doran



Outreach: Everyone is invited to be a member of our virtual imaging team

JUNOCAM

WELCOME TO THE JUNOCAM COMMUNITY WHERE YOU CAN ACTIVELY PARTICIPATE IN THE MISSION! UPLOAD YOUR IMAGES OF JUPITER AND HELP US DECIDE WHAT POINTS OF INTEREST JUNOCAM WILL PHOTOGRAPH.

▶ [LEARN ABOUT THE JUNOCAM](#)

↓ [JUNOCAM TECHNICAL PAPER](#)

PLANNING

Upload your telescopic images and data of Jupiter to help the team plan the mission

[GO TO PLANNING](#)

DISCUSSION

Create and comment on points of interest in Jupiter's atmosphere

[JOIN THE DISCUSSION!](#)

VOTING

Vote on points of interest for JunoCam to capture during its orbit of Jupiter

[VOTE!](#)

IMAGE PROCESSING

Browse other users' processed images from JunoCam or download, process, and submit your own images.

[PROCESSING GALLERY](#)

THINK TANK

See the scientific thought process in action as we learn about Jupiter's atmosphere from JunoCam's images.

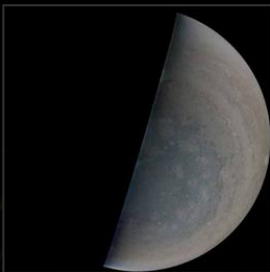
[CHECK IT OUT!](#)

www.missionjuno.swri.edu/junocam

JunoCam raw and lightly processed data

- We upload raw and lightly processed versions of the images
- Our citizen scientists download the data and do their own processing
- They are encouraged to upload their creations
- We enjoy science and art...

Image Version(s) Contained in Image Download : [↓ Images](#) [↓ Metadata](#)

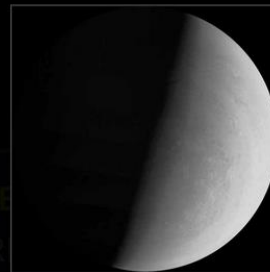


2017-05-19 08:15 UT

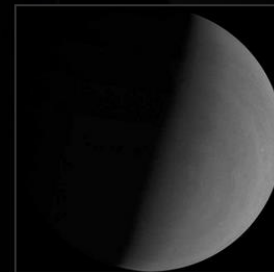


2017-05-19 08:59 UT

Red



Green



2017-05-19 08:15 UT

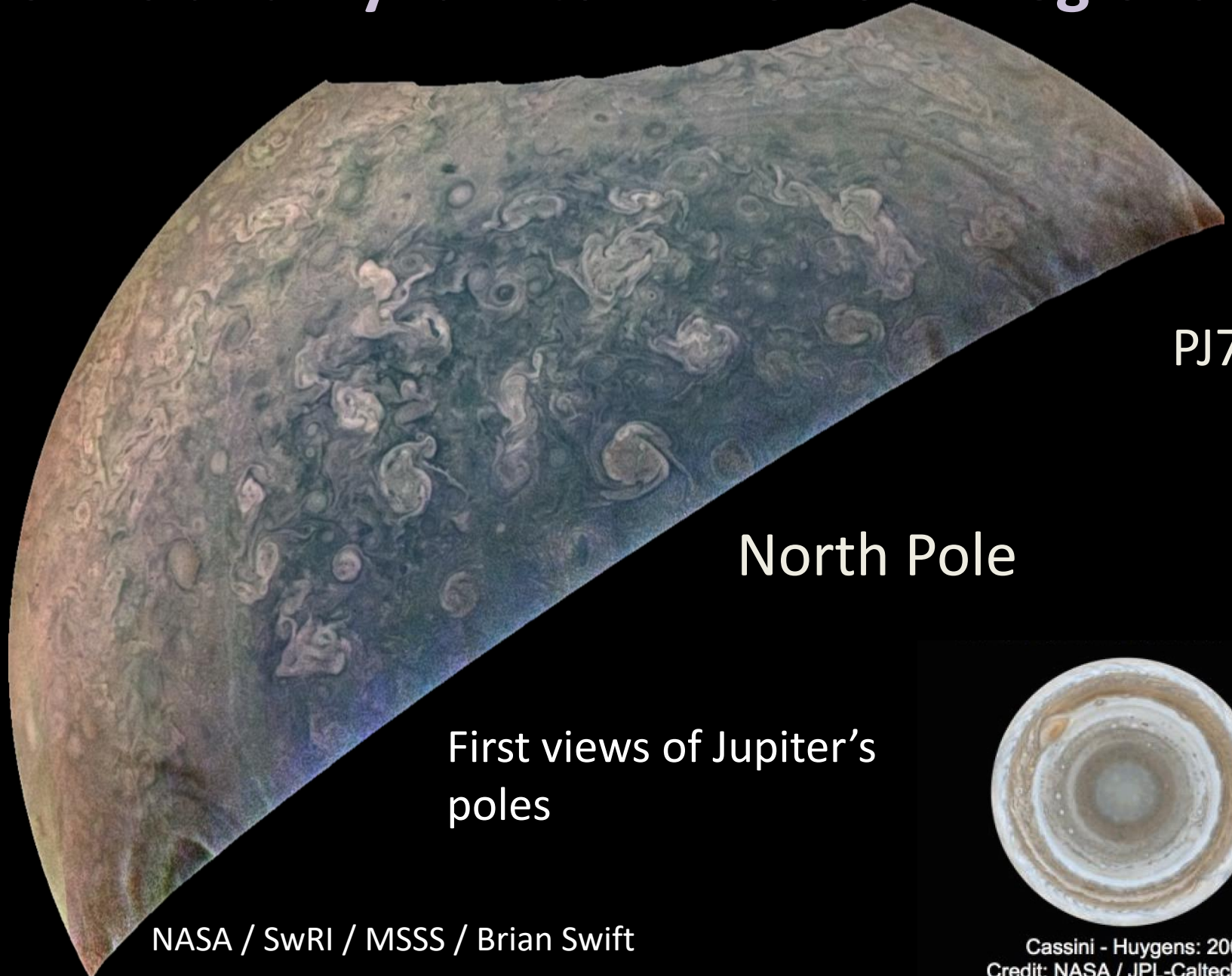
Blue

Science Investigations Underway

- Storms and dynamics at the poles
 - Circumpolar cyclones
- High altitude hazes and clouds; methane images
- Dynamics and the connection to the historic record
- “Pop-up” Storms
- Cloud colors and storm lifetimes
- Mesoscale Waves
- Great Red Spot structure

All enabled by the work of citizen scientists

Storms and Dynamics in the Polar Regions



First views of Jupiter's
poles

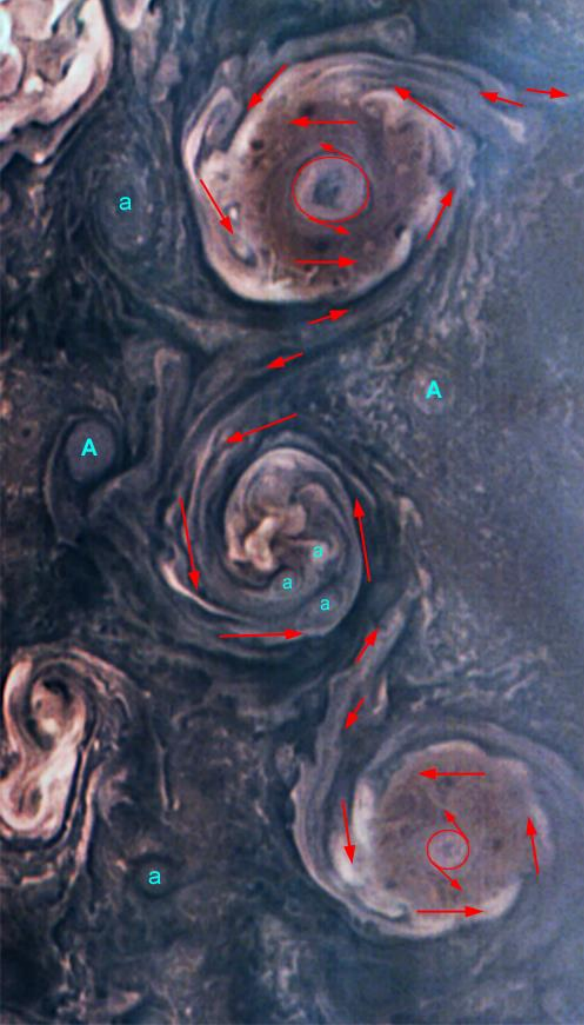
NASA / SwRI / MSSS / Brian Swift



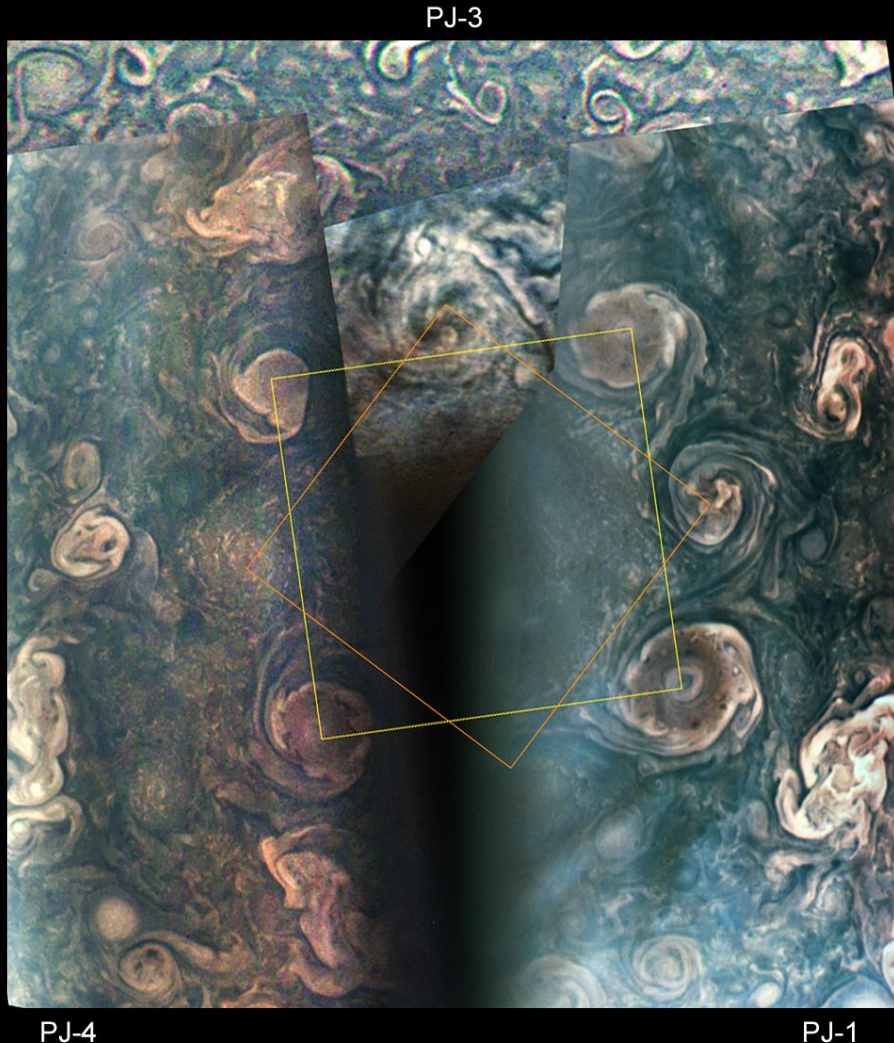
Cassini - Huygens: 2000
Credit: NASA / JPL-Caltech / SSI

Circumpolar Cyclones (CPCs) around Jupiter's North Pole

We were surprised to be able to detect motion — but this confirmed the cyclonic nature of the flow



Northern Circumpolar Cyclones



- 8 CPC's around north pole
- Successive perijoves find that the CPCs are extremely slow-moving in System III at the north pole
- CPCs in the north seem to form an octagon, but really a ditetragonal shape, consisting of two embedded 'squares' of unequal size

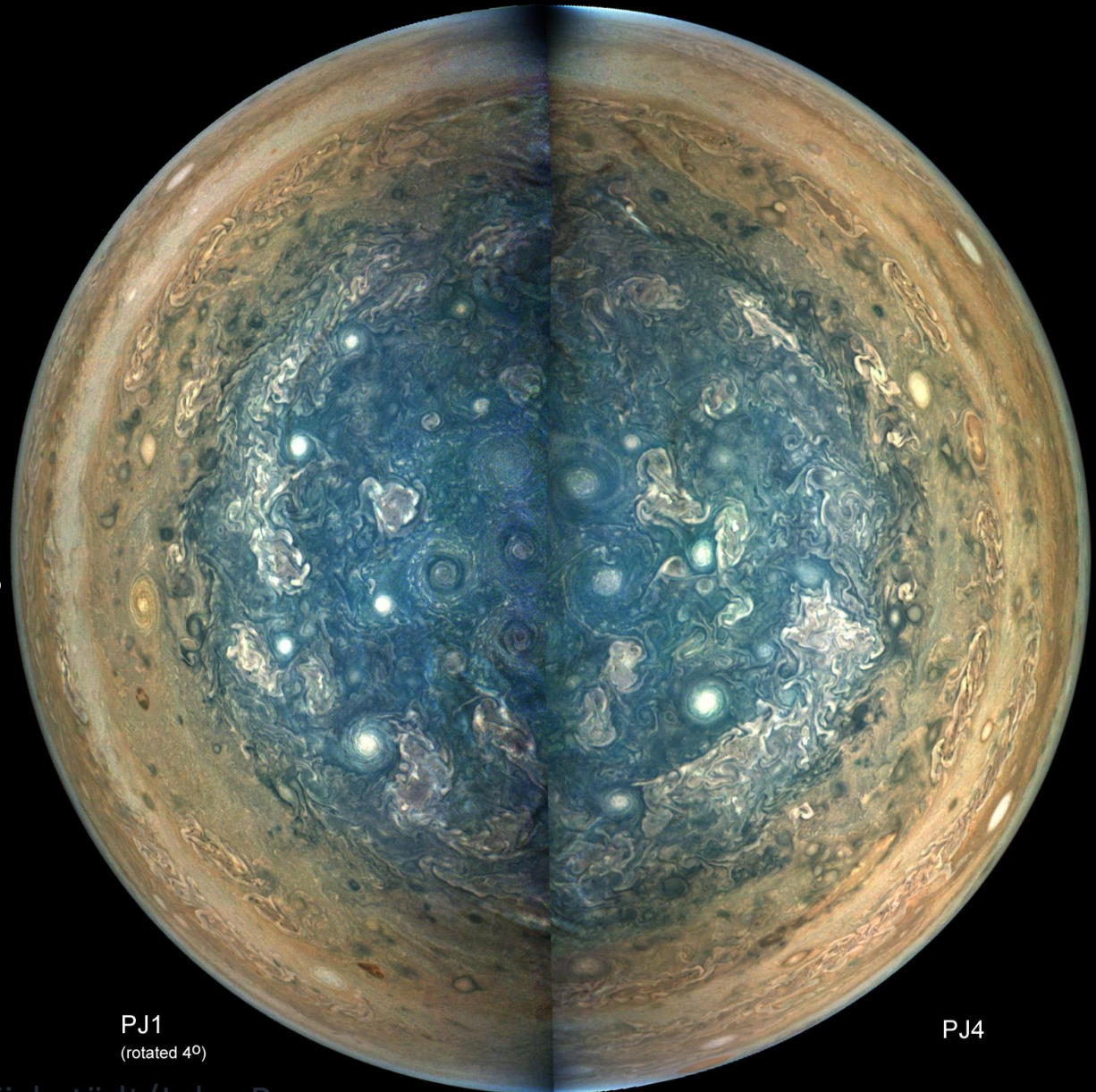
Exact north pole is in polar night right now

South Pole

South pole is visible
(southern summer)

5 circumpolar cyclones
– plus a gap

Will another cyclone
move in to fill the gap?



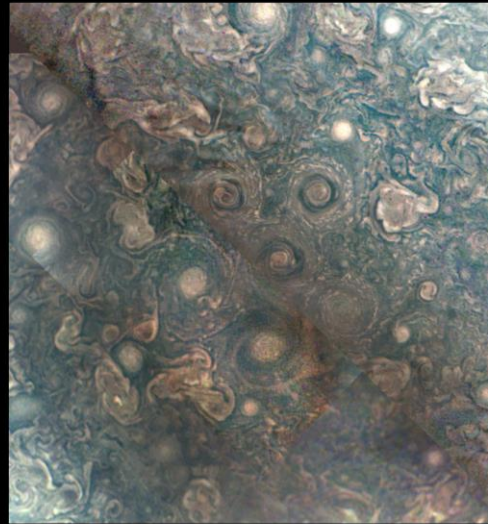
PJ1
(rotated 40°)

PJ4

South Polar CPCs

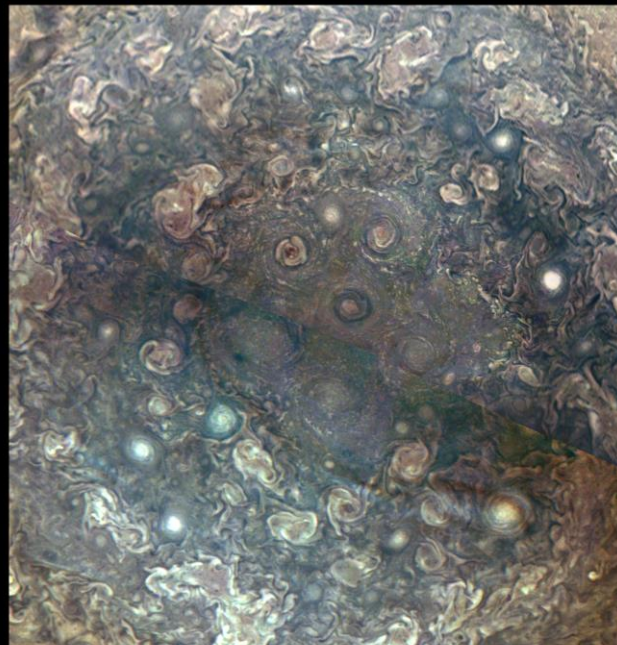
- 5 CPCs,
relatively stable
in System III
longitude from
PJ1 to PJ9 (over
a year)

PJ-1 (rotated -3.0 deg)



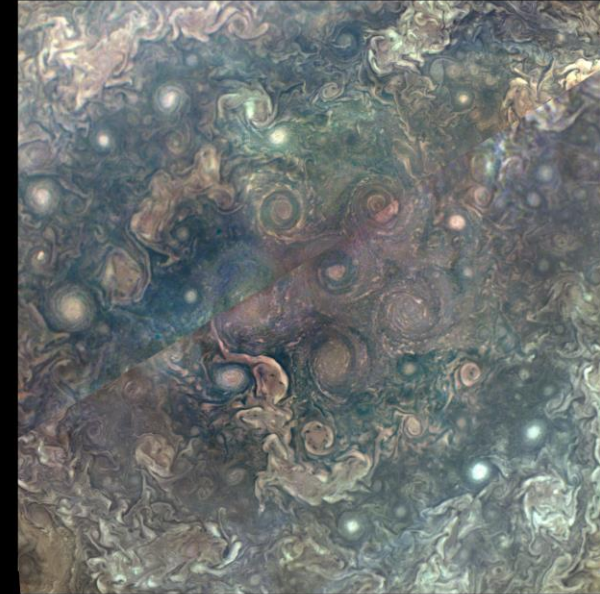
PJ-4

PJ-6 (rotated -4.0 deg)



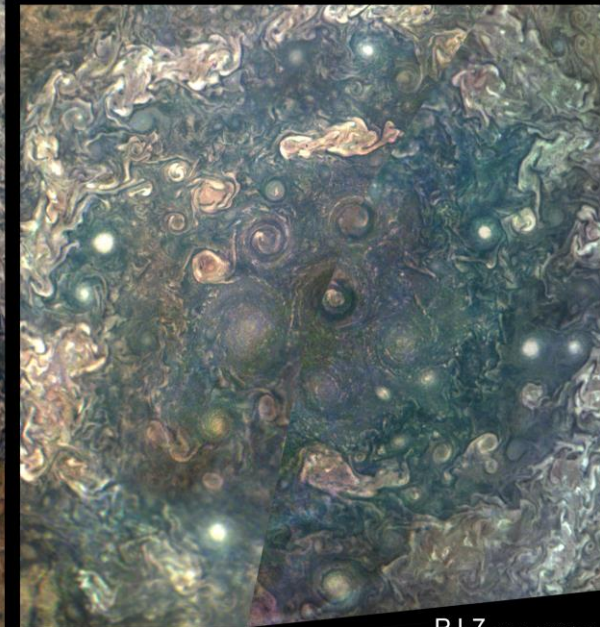
PJ-8

PJ-5



PJ-3 (rotated -4.0 deg)

PJ-9

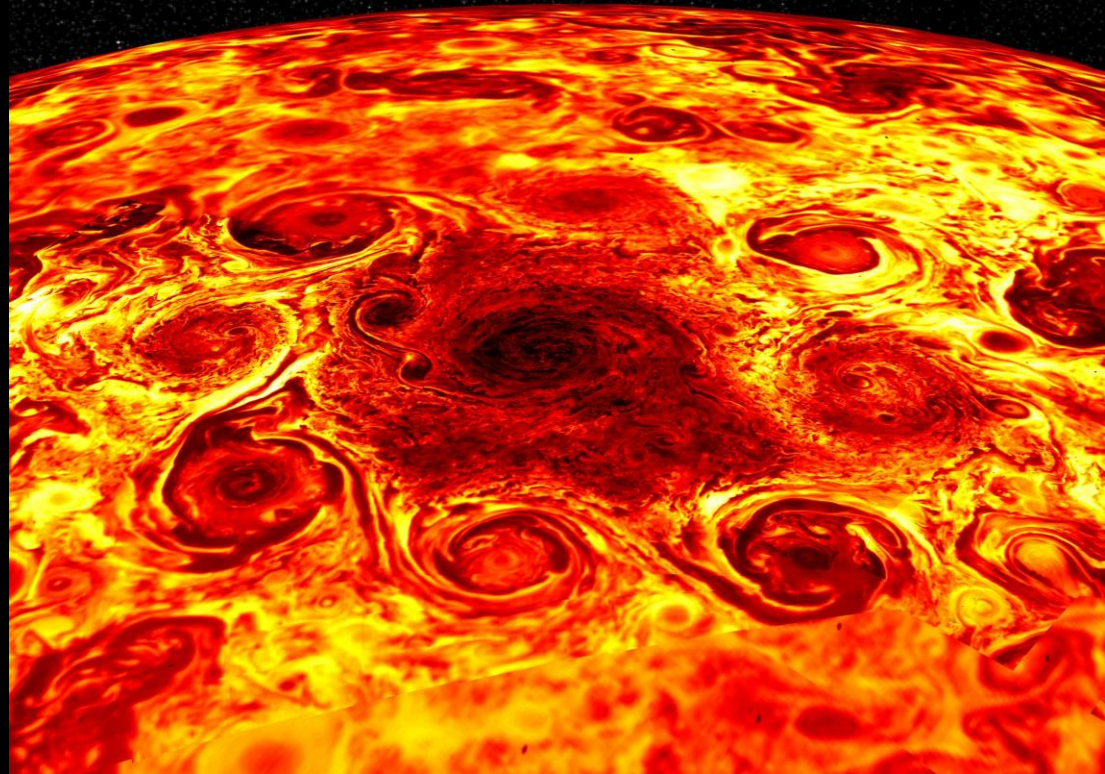


PJ-7 (rotated -6.0 deg)

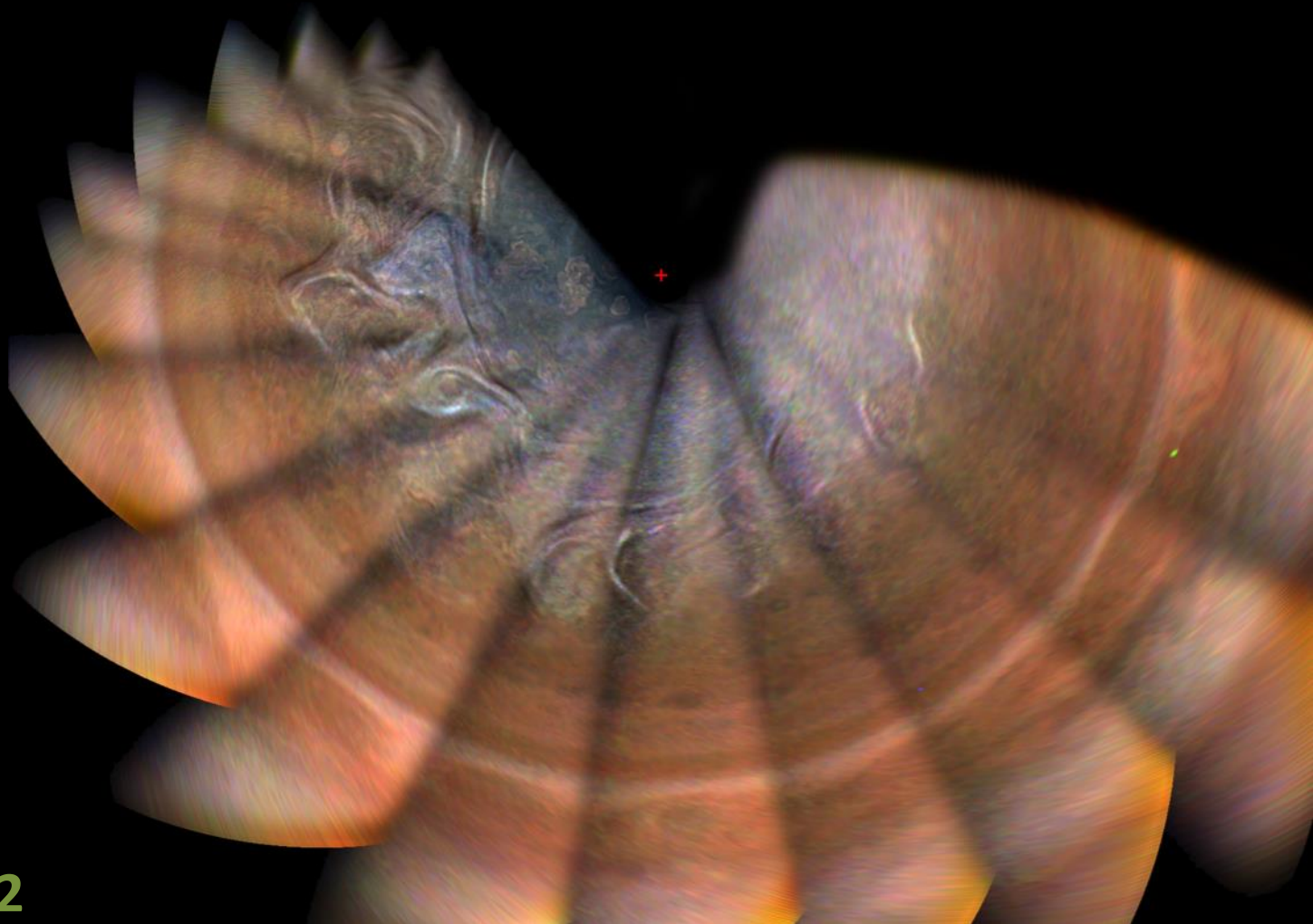
Results To-Date

Joint JIRAM and JunoCam paper published in
Nature: “Clusters of Cyclones encircling Jupiter’s
Poles”, *Nature* 555:216-219 (2018)

Adriani A., Mura A., Orton G., Hansen
C., Altieri F., Moriconi M.L., Rogers J.,
Eichstädt G., Momary T., Ingersoll A.,
Filacchione G., Sindoni G., Tabataba-
Vakili F., Dinelli B.M., Fabiano F.,
Bolton S.J., Connerney J.E.P., Atreya
S.K., Lunine J.I., Tosi F., Migliorini A.,
Grassi D., Piccioni G., Noschese R.,
Cicchetti A., Plainaki C., Olivieri A.,
M.E. O'Neill, Turrini D., Stefani S.,
Sordini R. and Amoroso M.



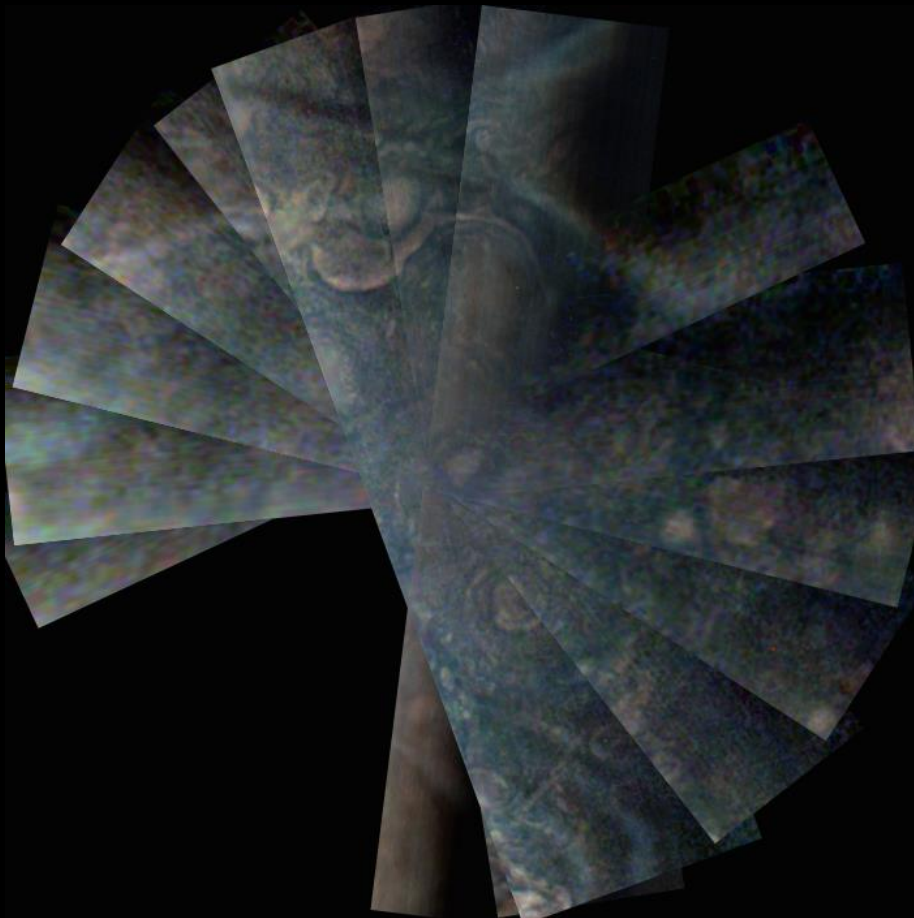
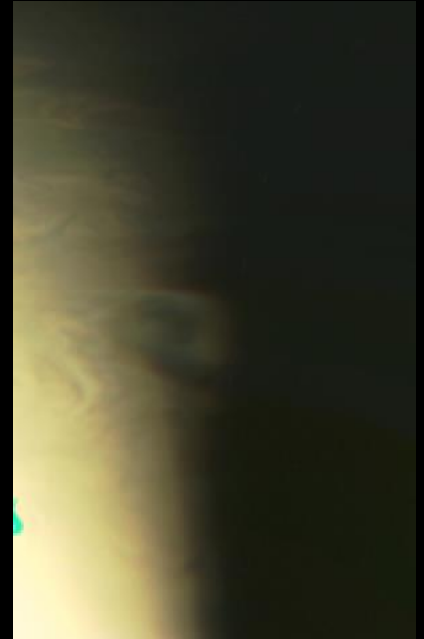
North Polar Hazes



PJ12

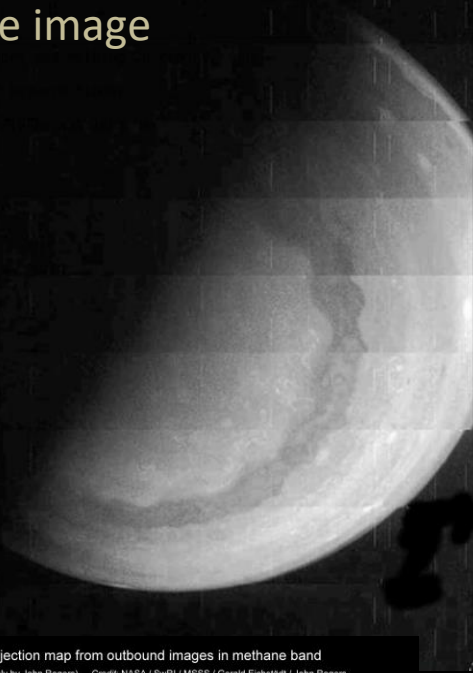
High Altitude Hazes and Clouds

Clouds illuminated above terminator, PJ1
~60 km high



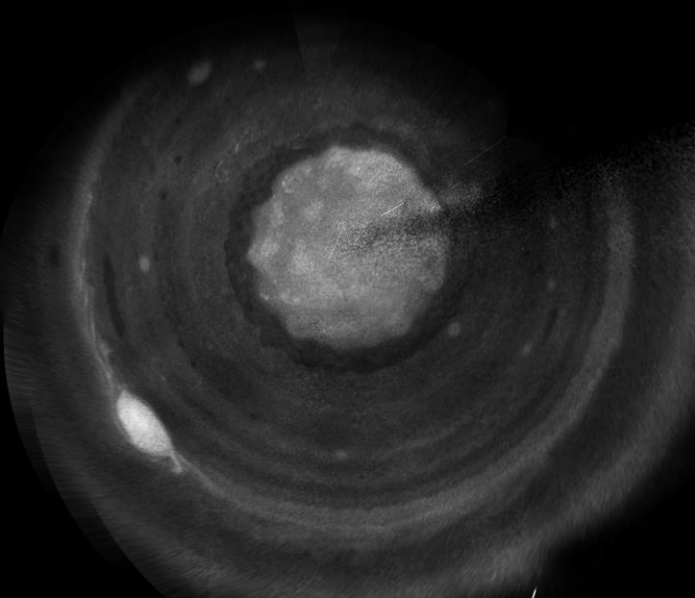
Bands of haze
PJ3, south pole

PJ9 methane image



Perijove-6: South polar projection map from outbound images in methane band
(Projections by Gerald Eichstädt, assembly by John Rogers) Credit: NASA / SwRI / MSSS / Gerald Eichstädt / John Rogers

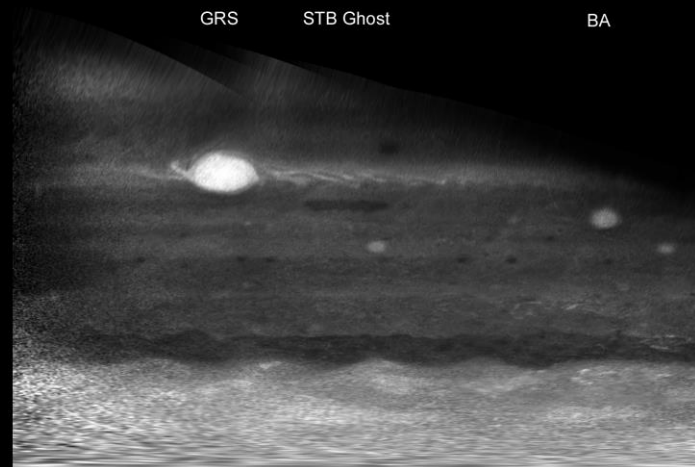
Compiled south polar projection



Methane Images

- JunoCam's methane filter images show (some) high hazes (the long haze bands aren't always visible)
- South polar hood waves visible

Perijove-6 (2017 May 19) Credit: NASA / SwRI / MSSS / Gerald Eichstädt / John Rogers
Methane map of southern hemisphere showing streak patterns in STropZ



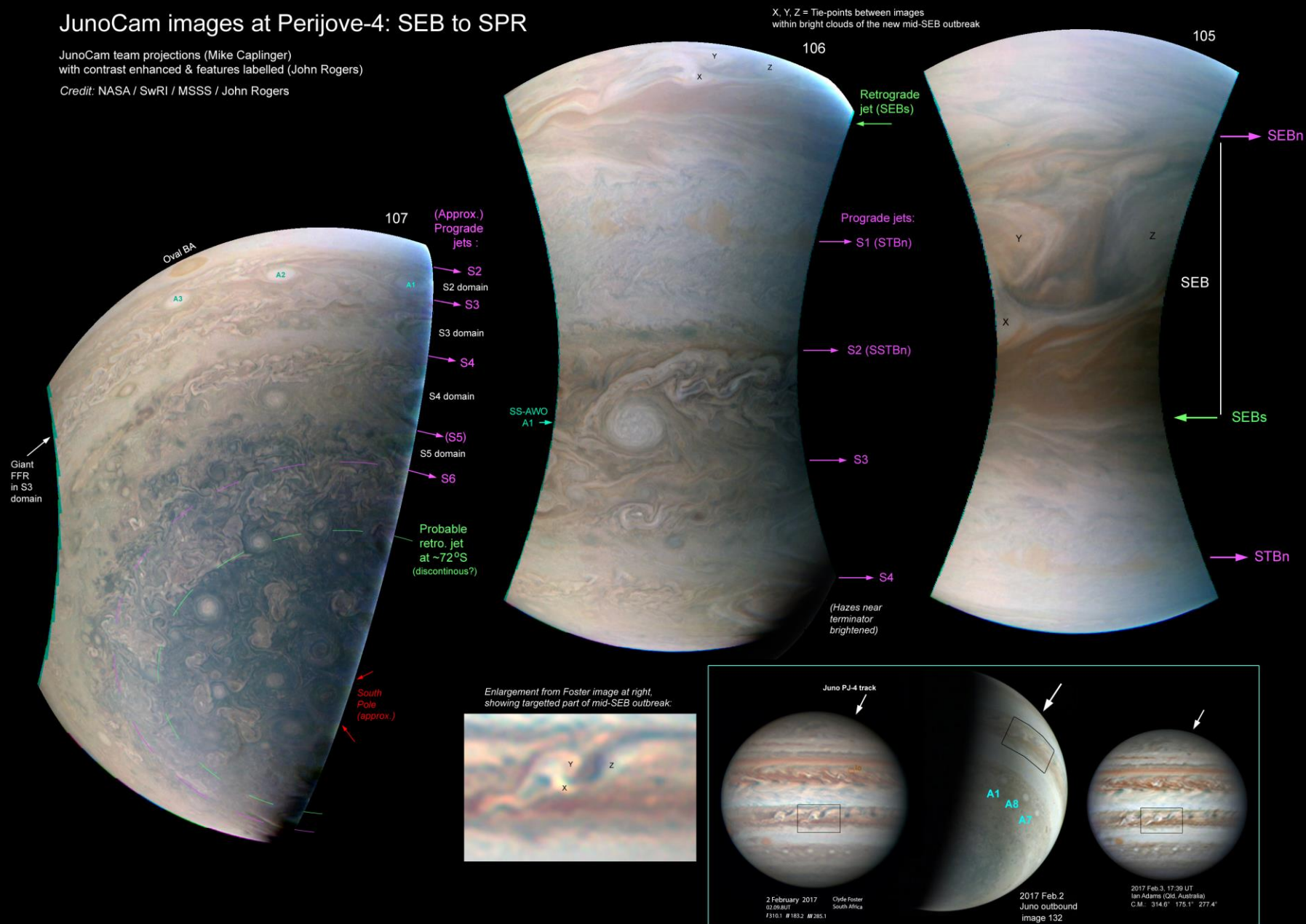
- ← Methane-bright streaks in northern STropZ, which was dark visually.
- ← Methane-bright S2-AWOs ('String of Pearls')
- ← Methane-dark spots are visibly white cyclonic spots on or near S3 prograde jet
- ← Bright strips in FFRs are methane-bright only in these v-hi-lat domains
- ← Edge of methane-bright S.P. Hood, with prominent waves (see polar projection)

Connection to Current and Historic Record

JunoCam images at Perijove-4: SEB to SPR

JunoCam team projections (Mike Caplinger)
with contrast enhanced & features labelled (John Rogers)

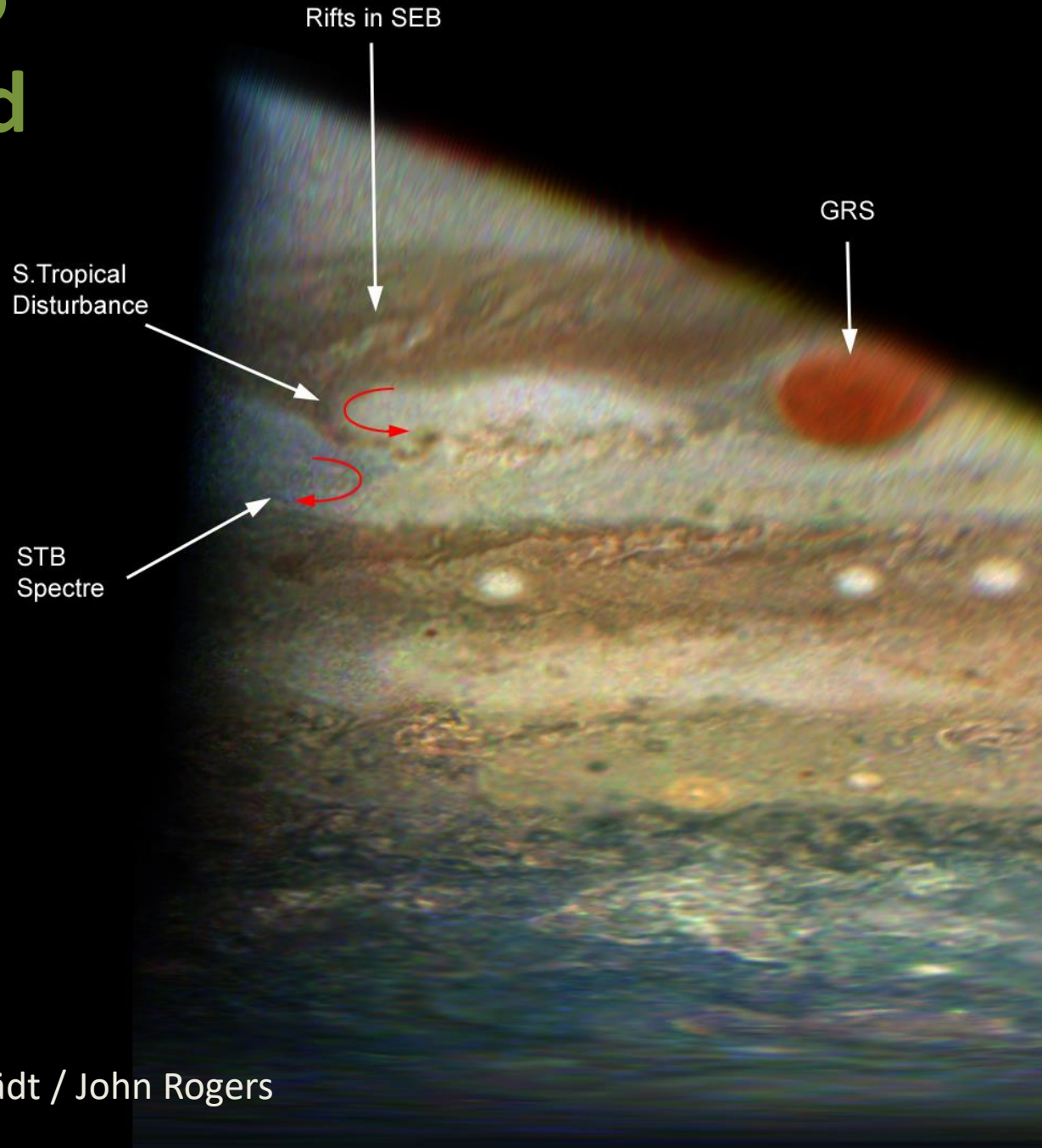
Credit: NASA / SwRI / MSSS / John Rogers



Connection to Historic Record illustrates Dynamics

South Tropical
disturbance started
up

Now interacting
with the GRS



Connection to Historic Record and Atmospheric Dynamics

The STB (South
Temperate Belt) Ghost

Timelapse sequence

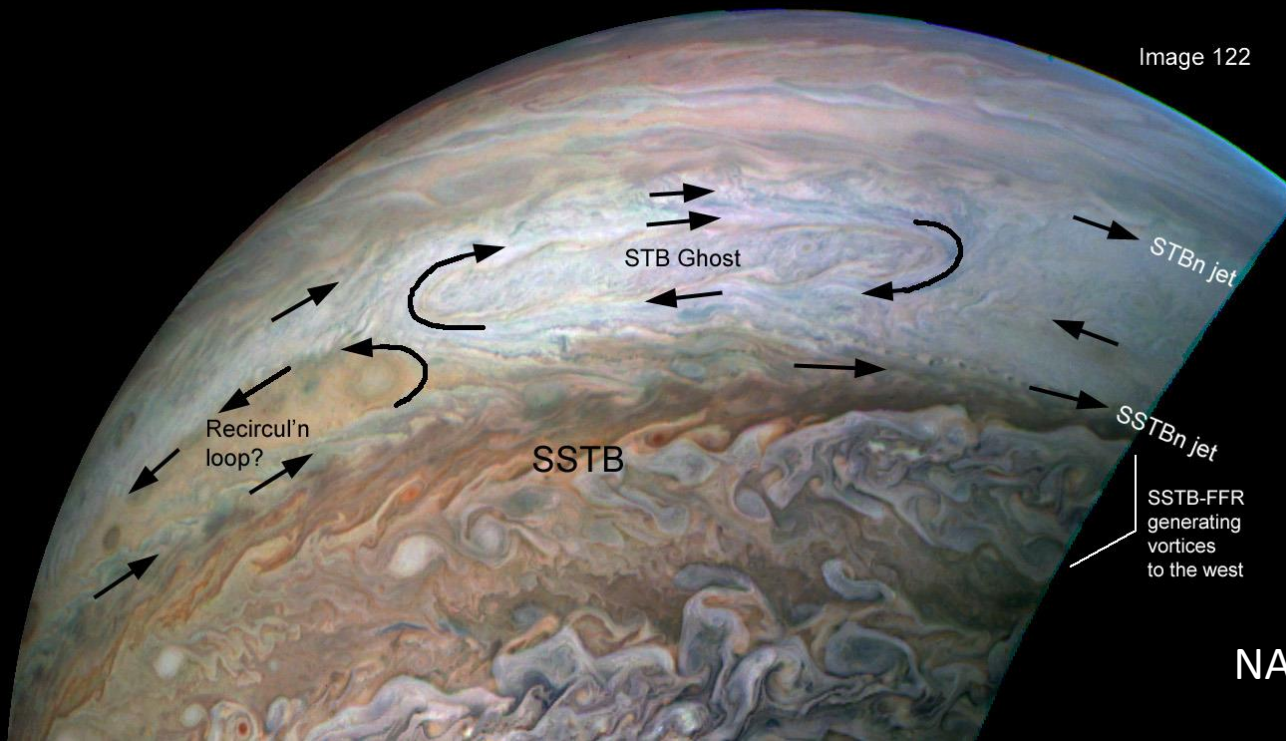


JunoCam, PJ8: The STB Ghost

Credit: NASA / SwRI / MSSS /
John Rogers

Likely locations of jets &
circulations are marked

The STB Ghost Circulation

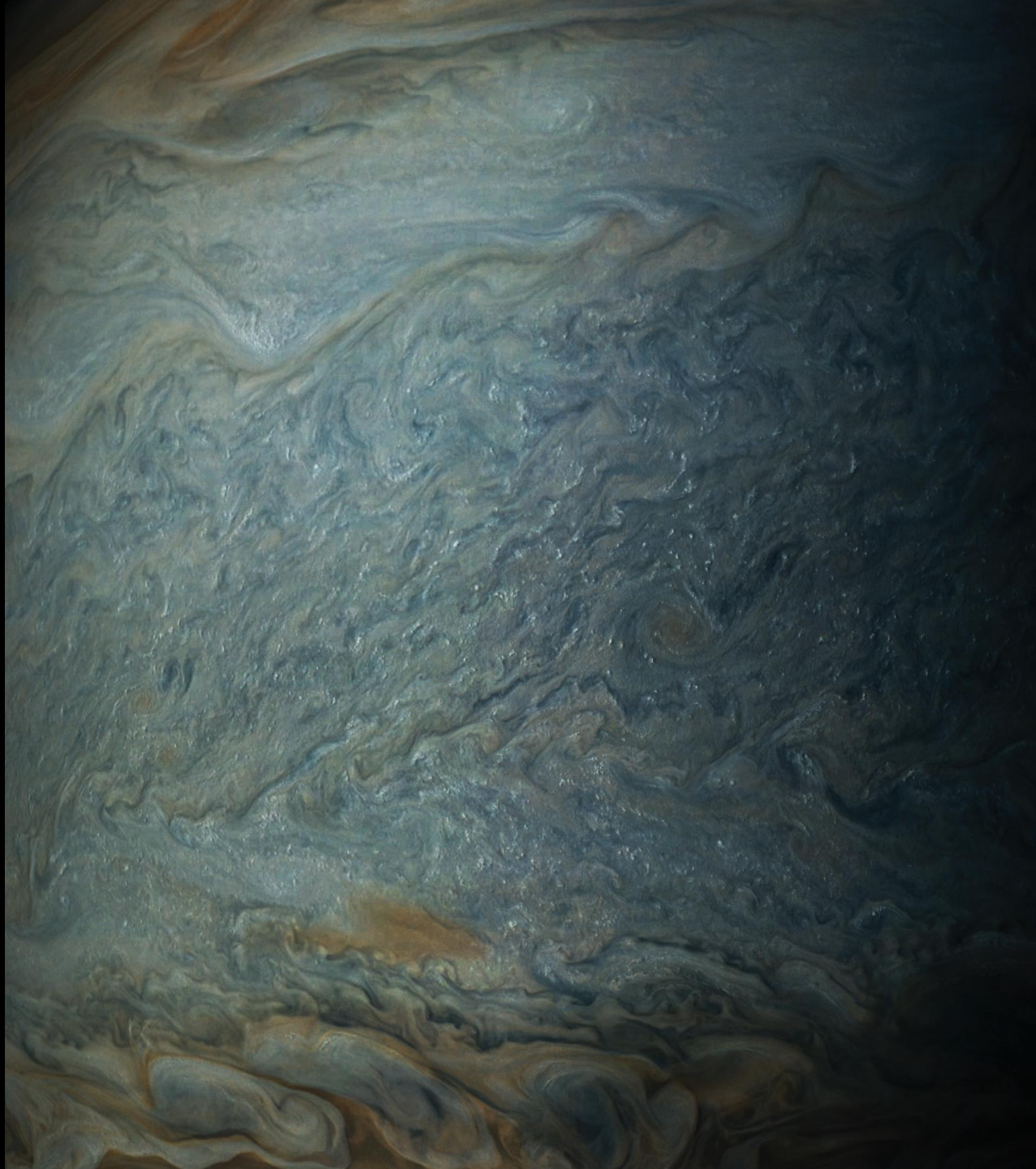


NASA / JPL / MSSS / John Rogers

“Pop-up” Storms in the South Tropical Zone



Why so many here?





Pop-up Storms

Not thunderheads – not correlated
with lightning

Shawn Brueshaber:
Are these the equivalent of earthly
altocumulous castellanus? (Signal
lapse rate instability and on earth
may be precursor to thunderstorms)



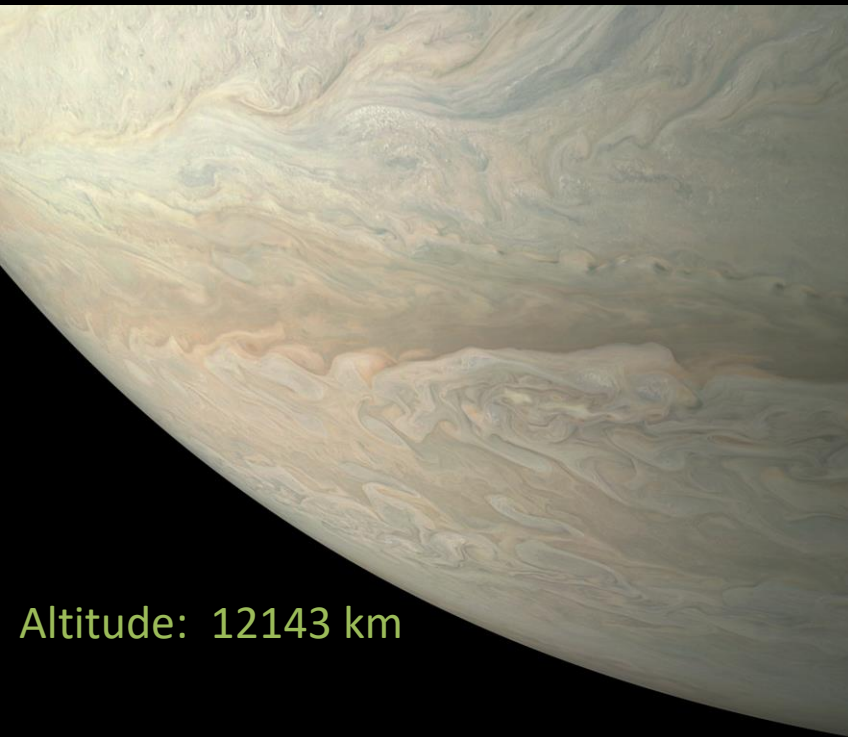
Clues from Clouds' Color



True Color



Images: NASA/JPL-Caltech/SwRI/MSSS Juno 2017-09-01 22:03:23 Product ID: JNCE_2017244_08C00118_V01 Image processing: Bjorn Jonsson



Altitude: 12143 km

Images: NASA/JPL-Caltech/SwRI/MSSS Juno 2017-09-01 22:03:23 Product ID: JNCE_2017244_08C00118_V01 Image processing: Bjorn Jonsson



Images: NASA/JPL-Caltech/SwRI/MSSS Juno 2017-09-01 22:03:23 Product ID: JNCE_2017244_08C00118_V01 Image processing: Bjorn Jonsson

2017-09-01 22:03

NASA / JPL / MSSS / Bjorn Jonsson

Color vs Lifetimes?

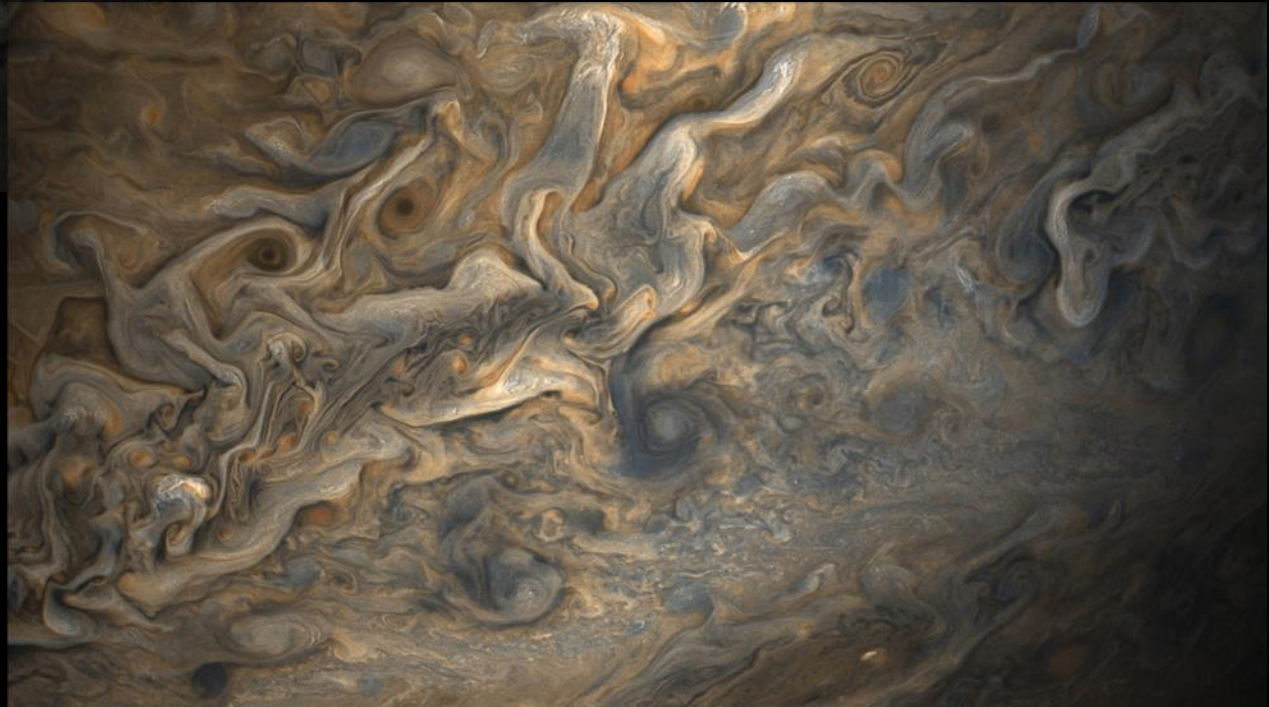
GRS color thought to be due to development of chromophores with long exposure to solar UV

Pairs of storms with noticeable color differences – dynamics vs lifetimes?



Northern Folded
Filamentary Regions

Southern hemisphere,
PJ9



Mesoscale Waves

PJ-12: Equatorial Zone

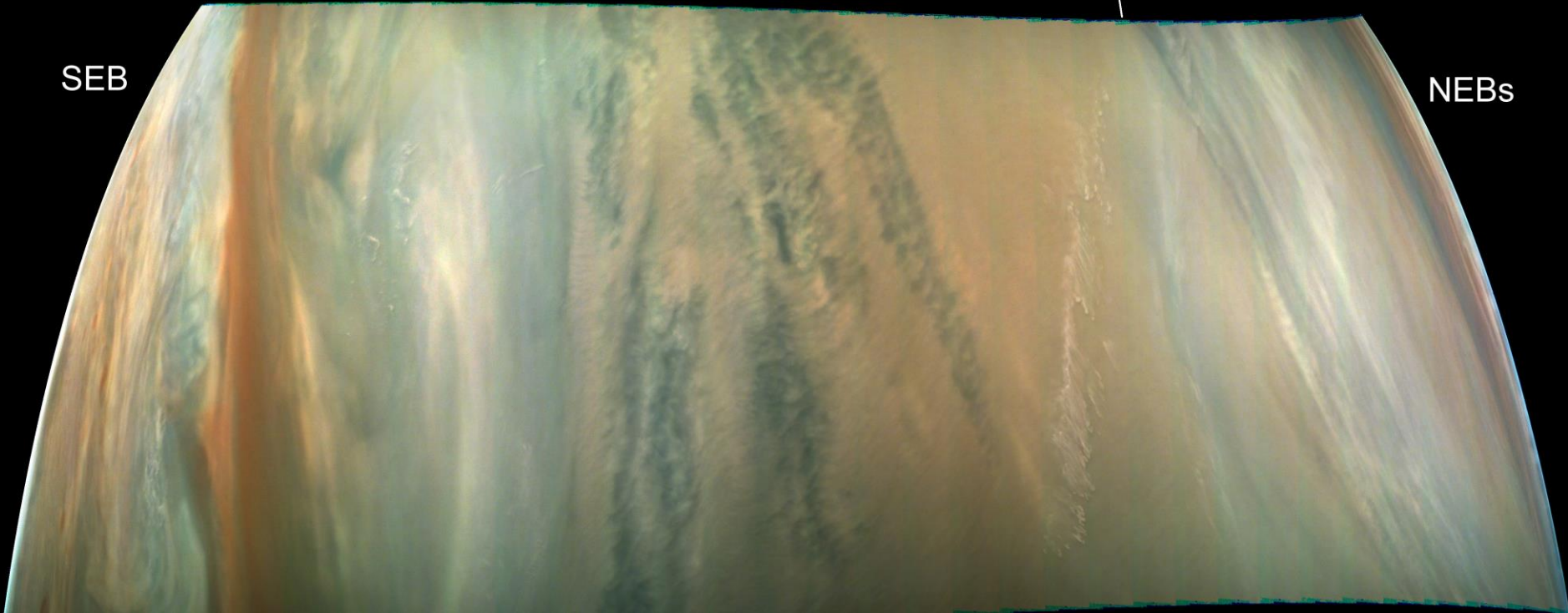
Credit: NASA / SwRI / MSSS / Gerald Eichstädt / John Rogers

Orange EB with mesoscale waves

→ N

SEB

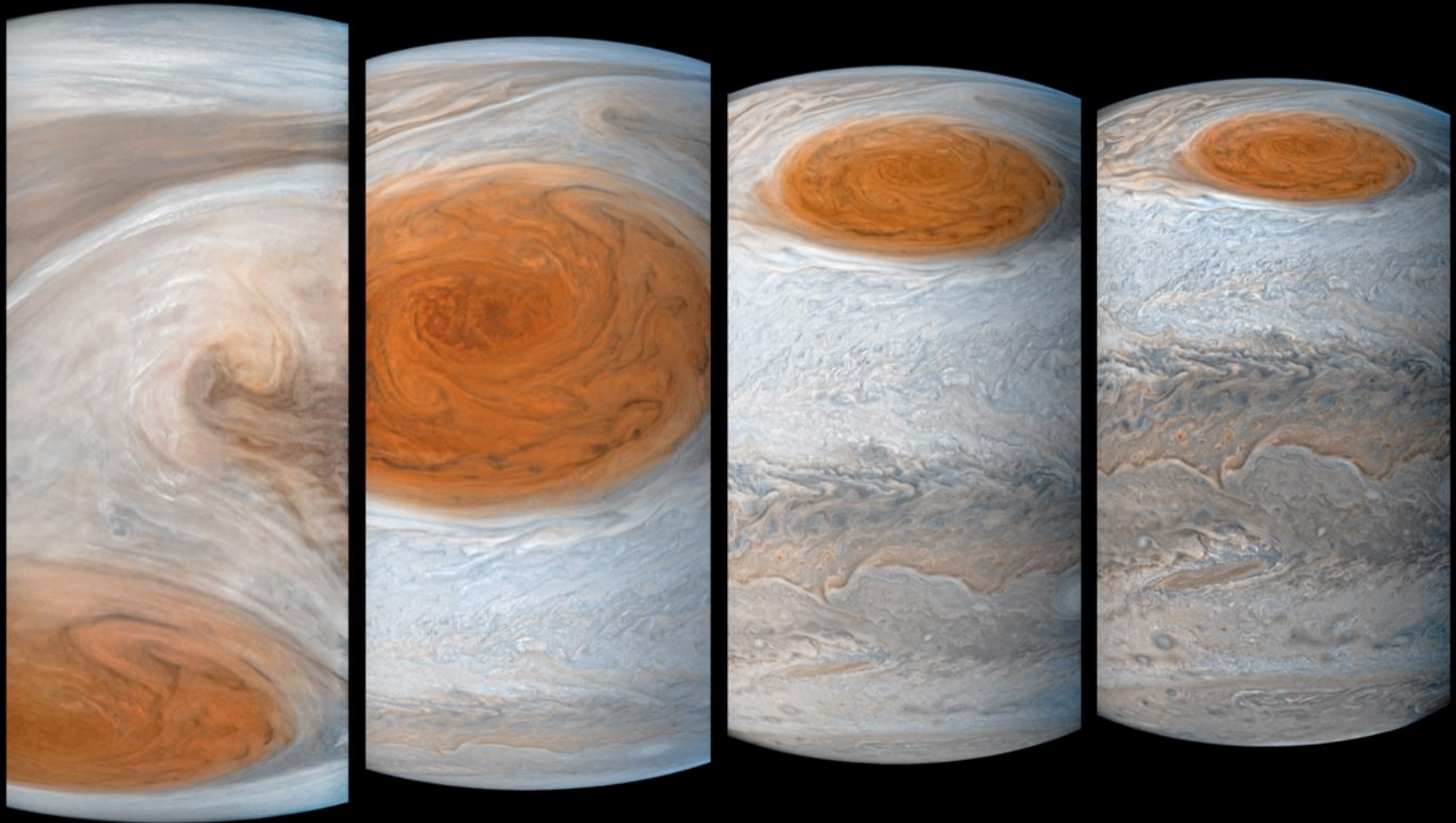
NEBs



2018-4-1 09:51

NASA / SwRI / MSSS / Gerald Eichstadt

Great Red Spot Structure

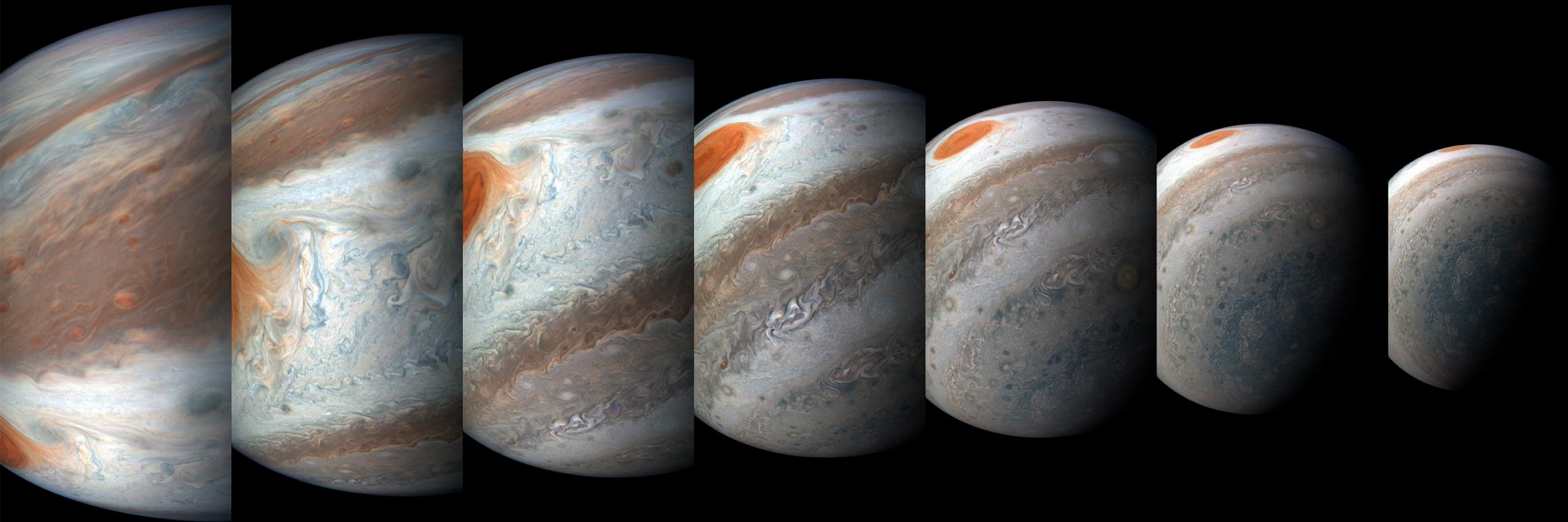


Altitude: 594 / – 16346 km
Spatial scale: 4 – 11 km/pixel
Subs/c latitude: -12.6 to -37.3

GRS captured in 4 images at perijove 7

NASA / JPL / MSSS / Gerald Eichstädt/Justin Cowart

PJ12 Southern Hemisphere Series



GRS interacting with South Tropical Disturbance

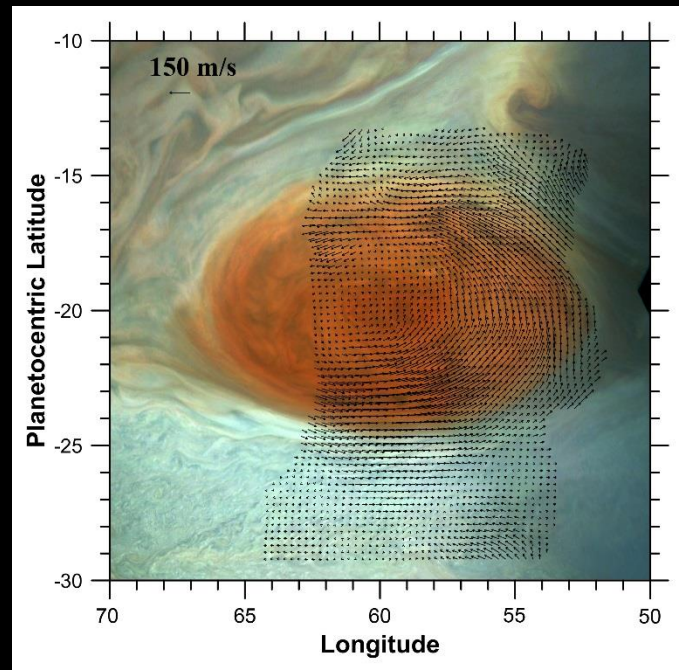
2018-4-1

NASA / SwRI / MSSS /Gerald Eichstadt/Sean Doran

Great Red Spot Dynamics



New Paper submitted:

- Sanchez-Lavega, A., R. Hueso, G. Eichstadt, G. Orton, J. Rogers, C. J. Hansen, T. Momary, F. Tabataba-Vakili, S. Bolton, “The Rich Dynamics of Jupiter’s Great Red Spot from JunoCam Images”, submitted to Astronomical Journal



New Think Tank Page

Sample Think Tank Contribution: Folded Filamentary Regions



MENU

Perijove 12
FFRs • waves • haze • GRS • CPCs
By Maquet-80 on 2018-04-22 UT
This thread will discuss Perijove-12 images. Perijove 12 was very rewarding: GRS, NN-WS-4, CPCs, FFRs, popup clouds, mesoscale waves, high phase angle observations of hazes, methane band images and an image stack, animations,...

SEE FULL THREAD

Folded Filamentary Regions (FFR)
FFRs • waves • haze • cyclones
By Maquet-80 on 2018-03-07 UT
Short-term observations of FFRs, long-term FFR statistics, attempts of data reduction, and modeling
Latest comment 2 weeks ago

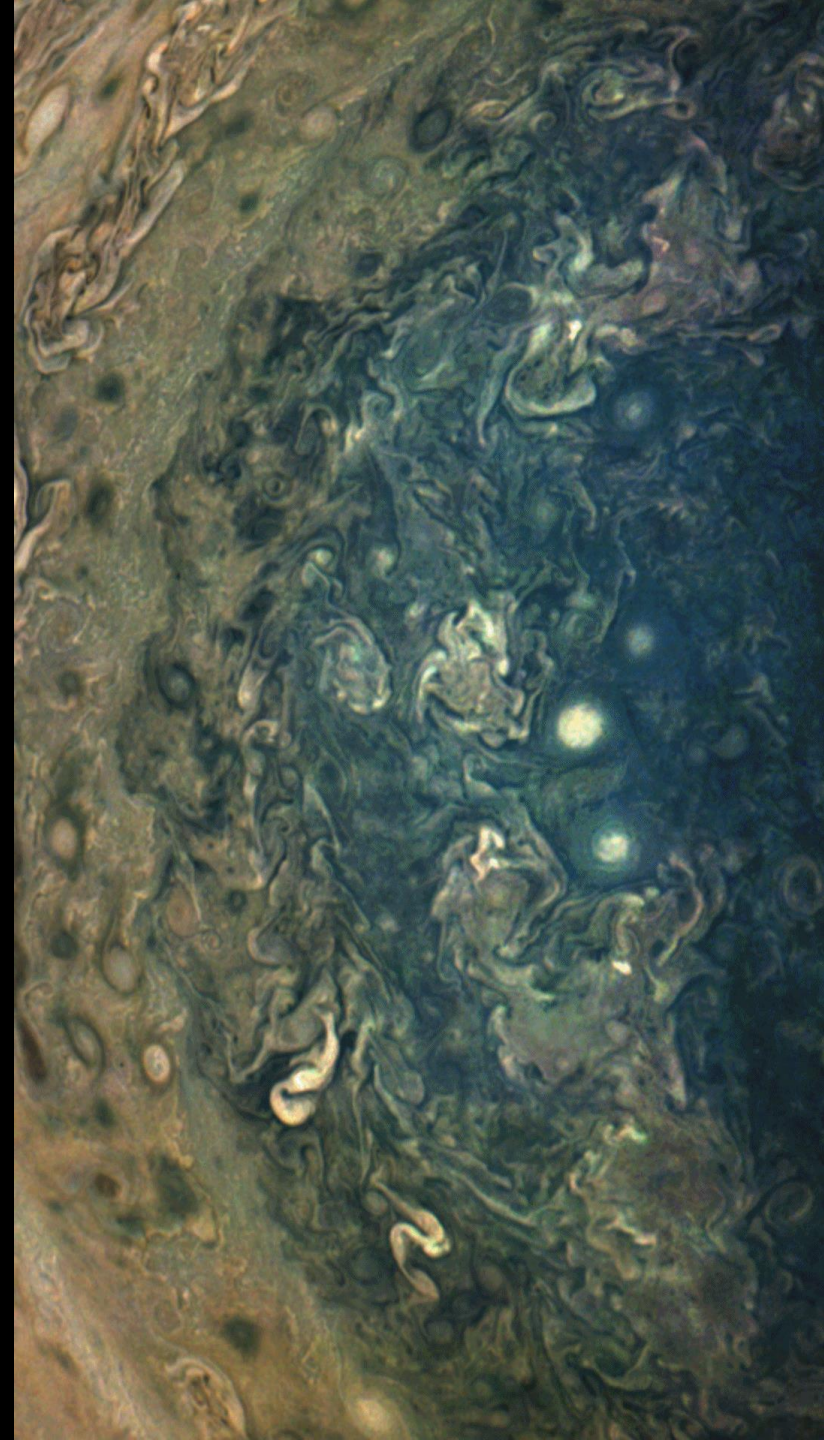
SEE FULL THREAD

Circumpolar Cyclones (CPC)
CPCs • cyclones
By Maquet-80 on 2018-03-07 UT
Short- and long-term observation of circum-polar cyclones, together with according interpretations and analysis.

www.missionjuno.swri.edu/junocam

From PJ10

NASA / SwRI / MSSS / Gerald Eichstadt



Questions?



